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Component Data Base for Space Station Resistojet Auxiliary Propulsion

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ABSTRACT

The resistojet has been baselined for Space Station auxiliary propulsion because of its operational versatility, efficiency, and durability. This report was conceived as a guide to designers and planners of the Space Station auxiliary propulsion system. It is directed to the low thrust resistojet concept, though it should have application to other station concepts or systems such as the Environmental Control and Life Support System (ECLSS), Manufacturing and Technology Laboratory (MTL), and the Waste Fluid Management System (WFMS). The report will likely be quite useful in the same capacity for other non Space Station systems including satellites, freeflyers, explorers, and maneuvering vehicles.

This report is a catalog of the most useful information for the most significant feed system components and is organized for the greatest convenience of the user.

INTRODUCTION

In August 1986 the resistojet was baselined for Space Station auxiliary propulsion. Propellant strategies and system designs have not been resolved. However, multipropellant capability has been baselined for the resistojets. This is predicated on the use of station waste fluids as propellants, simultaneously eliminating certain waste fluid management problems and resupply requirements [1,2]. The field of options is open to a wide variety of gaseous and liquid propellants and propellant handling strategies. Propellant selection has been tentatively narrowed to: inert gases, carbon dioxide, nitrogen, hydrogen, oxygen, water, and hydrazine. Some of these propellants have unique characteristics and applications that make them attractive candidates for Space Station auxiliary propulsion. Others are waste products from other systems onboard or on orbit with the Space Station. Table I shows the annual waste gas production for a Bosch ECLSS, Table II shows the same for a Sabatier ECLSS [3]. It is not expected that the exclusive use of waste products will be sufficient to meet the total impulse requirements of orbit maintenance. Therefore some propellant resupply for the exclusive use in the resistojets may be necessary if the main and auxiliary propulsion systems are to use different propellants.

Source strategies will be a major influencing factor in the selection of that propellant. The base propellant for auxiliary propulsion may be scavenged from other systems on the station. Hydrogen and/or oxygen may be derived from main propulsion storage, electrolysis of water or from Orbital Transfer Vehicle (OTV) tank farm boiloff. Nitrogen could be drawn from the ECLSS or be shared from an onboard pressurization system. CO_2 will be recovered from the ECLSS as a waste product of the breathing air recycling process. Methane may be recovered with the CO_2 depending on whether the Sabatier or the Bosch process is used. Water may be scavenged from the ECLSS as well though not necessarily as a waste product. Inert gases, such as argon, helium, xenon, and krypton would be recovered from the MTL as waste products, along with Freon and potentially any of the other above listed propellants excluding hydrazine. Recovering and using propellants that might otherwise be waste

products with handling problems would provide the advantage of operational cost savings.

Hydrazine has the advantage of low volume storage and broad experience base. Nitrogen's largest advantage is its handling safety. Since nitrogen is the major component in breathing air, a nitrogen system could be at least partially routed through a crew compartment, allowing easy access for maintenance or repair, without immediate concern for contamination due to leakage. Because the prior mentioned waste fluids, and potentially others not mentioned or yet identified, will likely be recovered from the ECLSS, MTL, and WFMS sections, a system will have to be developed for multipropellant operation. Matching components to multipropellant systems could be a challenge to the designer, particularly in the area of seat/seal material compatibility.

In order to reduce development cost and time it is desirable to reutilize existing component technology wherever possible. There is a significant number of components with space flight heritage. Enough of these components may have application to Space Station in their current design configuration or with minor modification to warrant a study resulting in compilation of all such available information.

The major components that apply to the Space Station auxiliary propulsion feed system include: connectors, tanks and accumulators, service valves, filters, pumps and compressors, pressure switches, check valves, pressure and temperature transducers, relief valves, pressure regulators, line and isolation valves, heaters, and gas generators. Fig. 1 compares the simplified propellant feed systems and their components. These are the components that will be cataloged in this report.

This report is intended to serve as a starting point for auxiliary propulsion design, trade studies, cost estimating, and planning. It is designed to contain as much data as possible for the purposes mentioned without being superfluous. The information contained herein was derived from many sources including: manufacturer's specifications and drawings, technical papers, and other data bases. Naturally, there are voids in the data provided. This was unavoidable as some data was not readily available during the preparation of this report. A disproportionately larger amount of effort would have been necessary to fill in all of the voids. It is up to the user to determine if, based on the data provided, further investigation is warranted to uncover additional data as required.

The information contained herein is organized into three sections for the sake of user indexing. The first is a list of the manufacturers covered in the catalog with last known address, phone, and contact for each. The second section is a fast index by component type including: feature specification, part number, manufacturer, and a cross reference to the next section. In this section, the difference between psia and psig is not always addressed because some data in certain categories was simply noted as psi. In such instances the gage and absolute notations are ignored and all pressures are noted as psi. The relative positions of these components in the index is correct to within one atm. The third and final section, the Component Data

Catalog section (pp. 55-381), is included as a microfiche supplement in an envelope stapled to the inside back cover of this report. Components within each type category are organized in 1) alphabetical order by the manufacturer, 2) in alphanumerical order by part number. In this section all available pertinent data for each component category is organized into data formats. Blank copies of these formats are given in the Component Data Sample Format section. The catalog section of this report is designed to be periodically updated. Contributors should use the blank formats to organize information to be changed, included or deleted. This information should be forwarded to Dan Briehl, Mail Stop 500-221, National Aeronautics and Space Administration, Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio 44135

In order to limit the field of coverage in the common component categories, general parameters have been defined for both gas and liquid feed systems, as follows: maximum system pressure - 6000 psi, maximum tank volume - 50,000 cubic inches, and minimum valve cycle life - 100. However, when regarding those components for which data is scarce, these parameters may be ignored. This allows the user a look at components that may at least be closely related to the components required. Further, some components that may have special applications will be included even though they do not conform to all of the parameters as defined. An example of this is the pyrotechnic valve with no cycle life. This valve could prove necessary in an emergency venting system. Component cost should be a significant factor in component selection, but because cost data has proved to be largely unavailable and cost restrictions are not yet defined; the catalog will not be limited by cost data.

There are other aspects to Space Station auxiliary propulsion system design to be considered when selecting components. The projected on-orbit life of the station is at least ten years. Components capable of a ten year service life would be logical candidates. The majority of the components qualified in space have not demonstrated a ten year service life with the throughputs projected for Space Station. To account for this, maintainability and redundancy become necessary considerations. The Space Station will be manned. Crew safety and therefore component safety and reliability are important considerations. The overall effort to develop, fabricate, and launch the Space Station will be costly. Component qualifications, cost, and weight are the balance of the important considerations. Unfortunately, at the time of writing, certain forms of component data were not readily available. Cost and reliability data will, in most instances, have to be acquired by the user of this document.

It will be desirable to reuse existing technology whenever possible to reduce development time and cost requirements in the development of the auxiliary propulsion system for Space Station. There are many qualified or qualifiable components available for consideration. This catalog should provide the propulsion system designer with a useful reference source to aid in design decisions.

ABBREVIATIONS AND ACRONYMS

abs - absolute

APS - auxiliary propulsion system

APU - auxiliary power unit

ARPCS - atmospheric revitalization & pressure control system

ASME - American Society of Mechanical Engineers

atm - atmosphere

BC - bolt circle

bhp - brake horsepower

C_D - discharge coefficient

CRES - corrosion resistant steel (includes stainless steel)

DI - deionized

ECLSS - environmental control & life support systems

ECS - environmental control system

EPR - ethylene propylene rubber

est - estimated

EQ SP - equally spaced

FEOD - flow equivalent orifice diameter

FS - full scale

G - gaseous

GPM - gallons per minute

HYD - hydraulic

i.d. - inner diameter

IOC - initial operational capability

L - liquid

lbf - pounds force

lbm - pounds mass

LH - left hand

LOA - length overall

LOX - liquid oxygen

LPM - liters per minute

max. - maximum

min. - minimum

MMH - monomethylhydrazine

MPS - main propulsion system

MTL - Manufacturing & Technology Laboratory

N.C. - normally closed

N.O. - normally open

nom. - nominal

NTO - nitrogen tetroxide

o.d. - outer diameter

OP - operational

PL - places

psi - pounds per square inch

psia - pounds per square inch, absolute

psid - pounds per square inch, differential

psig - pounds per square inch, gauge

RCS - reaction control system

RH - right hand

SCCH - standard cubic centimeters per hour

SCCM - standard cubic centimeters per minute

SCCS - standard cubic centimeters per second

SCFM - standard cubic feet per minute

Sh - sheet

SPDT - single pole double throw

SRB - solid rocket booster

std - standard

TBO - time before overhaul

TFE - tetrafluoroethylene (generic for Teflon)

UDMH - unsymmetrical dimethylhydrazine

WFMS - waste fluid management system

w/ - with

w/o - without

LIST OF MANUFACTURERS

Abex Corporation
Aerospace Division
3151 West 5th Street
Oxnard, CA 93030
Contact: M. W. Leisten - Product Sales Manager-Rotating
(805) 985-0217
D. L. Simpson - Product Sales Manager
Product: pump, valve

Aerodyne Controls Corporation
30 Haynes Court
Ronkonkoma, NY 11779
Contact: Richard B. Graeb - Director of Sales and Marketing
(516) 737-1900
Product: relief valve, check valve

Aeroquip Corporation
Aerospace Division
Jackson Plant
300 South East Avenue
Jackson, Michigan 49203-1972
Contact: Mark C. Schmidt - Sales Engineering Service Coordinator
(517) 787-8121
Product: fitting

Aircraft Porous Media
Pall Corporation
6301 49th Street North
Pinellas Park, FL 33565
(813) 522-3111
Product: filter
Ref. 4

Bendix Fluid Power Division
Allied Bendix Aerospace
211 Seward Avenue
P.O. Box 457
Utica, NY 13503
Contact: Louis A. Steppello - Senior Marketing Representative
(315) 793-1353
Richard Padgett - Director of Marketing
Product: compressor

Brunswick Defense Division
Brunswick Corporation
4300 Industrial Avenue
Lincoln, Nebraska 68504
Contact: Thomas R. Flynn - Director of Marketing
(402) 464-8211
Product: tank

Cajon Company
9760 Shepard Road
Macedonia, Ohio 44056
Product: fitting
Representative: Abbott Valve & Fitting Co.
6090 Cochran Road
Cleveland, Ohio 44139
(216) 248-6515
Contact: John Fant - Sales Representative

Carleton Technologies, Inc.
P.O. Box 28
East Aurora, NY 14052
Contact: James Walleshauser - Manager, Space Programs
(716) 652-8100
Product: pressure regulator, relief valve

CEC Instruments Division
Transamerica Delaval Inc.
325 Halstead Street
P.O. Bin 7087
Pasadena, CA 91190-7087
(818) 351-4410
Contact: Robert A. Bachus - Senior Applications Engineer
(818) 351-4241
James A. Vail - Account Manager (Dayton, Ohio)
(513) 252-1987
Product: pressure transducer

Circle Seal Controls
Brunswick Corporation
P.O. Box 3666
Anaheim, CA 92803
(714) 774-6110
Product: check valve

Consolidated Controls Corporation
Condec Corporation
15 Durant Avenue
Bethel, CT 06801
Contact: Peter D. VanVessem - Chief Project Engineer
(203) 743-6721
James L. Costanza - Manager, Technical Marketing (El Segundo, CA)
M. T. Petrozzi - Marketing Manager, Space Components (El Segundo, CA)
(213) 772-5301
Product: pressure regulator, pressure switch, pressure transducer, service valve, line/thruster valve

Deutsch Metal Components
14800 South Figueroa Street
P.O. Box 61188
Los Angeles, CA 90061
Contact: Clement Law - Media Specialist
(213) 321-3040
Product: fitting

Facet Enterprises, Inc.
Filter Products Division
8439 Triad Drive
Greensboro, NC 27409-9621
(919) 852-6800
Product: filter

Fairchild Control Systems Company
1800 Rosecrans Avenue
Manhattan Beach, CA 90266-3797
(213) 643-9222
Product: pressure regulator
Ref. 4

Fansteel, Inc.
5235 West 104th Street
Los Angeles, CA 90045
(213) 670-1030
Product: tank
ref. 5

Futurecraft Corporation
15430 Proctor Avenue
City of Industry, CA 91747
Contact: James J. Castor - Engineering/Sales Manager
(818) 330-1611
Product: check valve, relief valve, line/thruster valve, pressure regulator

Garrett Corp.
AiResearch Mfg. Co. Division
2525 West 190th Street
Torrance, CA 90509
(213) 323-9500
Product: tank
ref.5

HTL Industries, Inc.
Allegheny International Company
101 East Wheeler Avenue
Arcadia, CA 91006
(213) 574-7880
Product: service valve
ref. 4

Hughes Aircraft Company
Space & Communications Group
Box 92919
Los Angeles, CA 90009
(213) 648-2345
Product: service valve
ref. 4

ITT Neo-Dyn
21411 Prairie Street
P.O. Box 3789
Chatsworth, CA 91311
(818) 998-8611
Contact: Jeffrey D. Anderson - Regional Sales Manager-Airborne
(313) 329-9082
Product: pressure switch

Lexair Inc.
299 Goldrush
Lexington, KY 40503
Contact: C. W. Allen - President
(606) 278-5001
Product: compressor

Marotta Scientific Controls, Inc.
Boonton Avenue
Boonton, NJ 07005
(201) 334-7800
Product: pressure regulator
ref. 4

The Marquardt Company
16555 Saticoy Street
Van Nuys, CA 91409
Contact: Tom E. Hudson - Manager, Rocket Applications
(818) 989-6400
Product: gas generator (water vaporizer)

Martin Marietta Corporation
Denver Division
P. O. Box 179
Denver, CO 80201
(303)794-5211
Product: tank
ref. 5

Metal Bellows Division
Parker Bertea Aerospace Group
1075 Providence Hwy
Sharon, MA 02067
Contact: John Barrett - Marketing Manager
(617) 668-3050
Product: compressor, accumulator

Moog Inc.
Space Products Division
East Aurora, NY 14052-0018
Contact: Jay Hennig - Sales & Marketing Engineer
(716) 687-4499
Douglas H. Morash - Engineering Manager
(716) 652-2000
Product: line/thruster valve, service valve, pump

Norman Equipment Company
Norman Filter Division
9850 South Industrial Drive
Bridgeview, Il 60454
Contact: O. Garapolo - Vice President-Filter Division
(312) 430-4000
Representative: Stanley M. Proctor Company
Box 446, Twinsburg, Ohio 44087
(216) 425-7814
Product: filter

Paine Corporation
2401 South Bayview Street
Seattle, WA 98144
(206) 329-8600
Product: pressure transducer

Pall Pneumatic Products Corporation
Pall Corporation
2200 Northern Boulevard
East Hills, NY 11548
Contact: Edward J. Murphy - Marketing Manager
(516) 484-5400
Product: filter

Parker Hannifin Corporation
Air and Space Products Division (Parker Aerospace)
18321 Jamboree Blvd.
P. O. Box C-19510
Irvine, CA 92713
Contact: William Hostetler - Marketing Manager
(714) 833-3000
Product: valve

Pressure Systems, Inc.
2017 Camfield Avenue
Los Angeles, CA 90040
(213) 685-4520
Product: tank
ref. 5

Purolator Technologies
H R Textron
2323 Teller Road
Newbury Park, CA 91320
(805) 499- 2661
Product: filter

Pyronetics Devices, Inc.
OEA, Inc.
P. O. Box 10488
Denver, CO 80210
(303) 693-1411
Product: service valve
ref. 4

Resistoflex Company
UMC Industries, Inc.
Roseland, NJ 07068
(201) 226-7700
Anaheim, CA 92803
(714) 772-4700
Product: fitting

Rocket Research Corporation
York Center
Redmond, WA 98052
Contact: J. J. Galbreath
(206) 885-5000
Product: gas generator (thruster)
ref. 5

Rockwell International
Space Division
12214 Lakewood Blvd.
Downey, CA 90241
(213) 594-3838
Product: tank
ref. 5

Snap-Tite
Quick Disconnect Division
Union City, PA 16438
(814) 438-3821
Product: fitting

Statham Division
Solartron Transducers
2230 Statham Boulevard
Oxnard, CA 93033
(805) 487-8511
Product: pressure transducer

Sterer Engineering & Manufacturing Company
Box 39787
4690 Colorado Blvd
Los Angleles, CA 90039
Contact: J. Pauly
(213) 245-7161
Product: pressure regulator
ref.4

Structural Composites Industries (SCI)
Harsco Corporation
325 Enterprise Place
Pomona, CA 91768
Contact: Vicki Lynn - Marketing Engineer
(714) 594-7777
Product: tank

Systron Donner
Edcliff Division
1711 South Mountain Avenue
Monrovia, CA 91016-0727
Contact: Gordon L. Glau - Applications Engineering Manager
(818) 358-4571
Product: pressure transducer, pressure switch

Tavco, Inc.
20500 Prairie Street
Chatsworth, CA 91311
(818) 882-5411
Product: pressure regulator
ref. 4

TRW
One Space Park
Redondo Beach, CA 90278
(213) 535-4321
Product: service valve, pressure regulator, gas generator (thruster)
ref. 4

Vacco Industries
10350 Vacco Street
South El Monte, CA 91723
(213) 443-7121
Product: filter
ref. 4

Valcor Engineering Corporation
2 Lawrence Road
Springfield, NJ 07081
Contact: Bernard W. Quail - Vice President Sales Engineering
(201) 467-8400
Product: valve

Weed Instrument Company, Inc.
707 Jeffrey Way
P. O. Box 300
Round Rock, TX 78680-0300
Contact: Bill Byrd - Division Manager-Nuclear,Aerospace
(512) 255-7043
Product: temperature transducer

Western Filter Corporation
P.O. Box 3685
8968 Fullbright Avenue
Chatsworth, CA 91313-6158
Contact: Phillip Flor - Fluid Power Sales Manager
(818) 886-8450
Product: filter

Whittaker Controls Division
12838 Saticoy Street
North Hollywood, CA 91605
(818) 765-8160
Product: pressure regulator
ref. 4

Wiggins Connectors Division
Transamerica Delaval, Inc.
5000 Triggs Street
Los Angeles, CA 90022
(213) 269-9181
Product: fitting

Wintec
Brunswick Technetics
2313 South Susan Street
Santa Ana, CA 92704
Contact: Harry Buehrle - Marketing Manager
(714) 966-0831
Product: filter, service valve

Wright Components, Inc.
An EG&E Company
Route 96
P. O. Box 160
Phelps, NY 14532
Contact: C. J. Weeks - Sales Manager
(315) 548-9501
Product: valve

FAST COMPONENT INDEX
Fitting/Connector

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Tank/Accumulator

Volume (in^3)	Pressure (psig)	Part Number	Manufacturer	Page
1631	3600	Model 156	SCI	82
3008	4500	BLD999030	Brunswick Defense	70
3008	4000	BLD999040	Brunswick Defense	71
8181	4500	BLD999020	Brunswick Defense	69
8181	3300	BLD999050	Brunswick Defense	72
8181	3300	BLD999060	Brunswick Defense	73
10,200	1500	(Grumman)LSC-270-821	Garrett AiResearch	76
11,000	3000	Model 200	SCI	83
13,442	300	80140-1	Pressure Systems	80
13,478	700	942-D-03	Fansteel	74
14,750	400	80801B36220-049	Martin Marietta	77
17,300	600	240-48202	Rockwell Internt'l	81
30,033	4875	BLD999010	Brunswick Defense	68
34,560	320	851240	Garrett AiResearch	75
35,300	890	80111-1	Pressure Systems	79
53,910	3000	88-4000500	Martin Marietta	78

FAST COMPONENT INDEX
Service Valve

Pressure (psi)	Part Number	Manufacturer	Page
295	1-4-00-51-45	Carleton Technologies	86
315	12319	Wright Components	107
345	72855	Consolidated Controls	89
350	12183	Wright Components	106
365	1821-1	Pyronetics	103
415	325-7167	Hughes Aircraft	94
500	900490	Futurecraft	91
500	900491-1	Futurecraft	92
510	50-527	Moog	95
510	50-528	Moog	96
510	50-529	Moog	97
510	50-530	Moog	98
535	1176-16, 1832-1	Pyronetics	100
555	1831	Pyronetics	104
600	409708	TRW	105
1000	200791	Futurecraft	90
1250	1-4-00-51-27	Carleton Technologies	84
1250	1-4-00-51-43	Carleton Technologies	85
3015	71665	Consolidated Controls	87
3015	1811-4	Pyronetics	101
3615	72580	Consolidated Controls	88
4015	255620-3, 255921-3	HTL Industries	93

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Filter

Pressure (psi)	Rating (μm abs)	Part Number	Manufacturer	Page
50	5	11267-504	Wintec, Brunswick	136
80	20(nom)	1736760-05	Facet	113
100	3 to 250 (nom)	1740001	Facet	114
150	-	PCS 13501 G24	Pall Corporation	117
150	-	8228-501	Wintec, Brunswick	135
180	5	AC-6875-4	Aircraft Porous Media	109
186	74	15204-516	Wintec, Brunswick	141
196	15	15241-526	Wintec, Brunswick	144
250	18	15241-508	Wintec, Brunswick	143
300	-	PCS 33501 G24	Pall Corporation	118
300	35	F1D10093	Vacco Industries	122
300	10	F1D10151-01	Vacco Industries	126
300	10	15267-603	Wintec, Brunswick	149
315	10	F1D10064-01	Vacco Industries	121
315	60	12204-508	Wintec, Brunswick	137
330	25	14228-621-3	Wintec, Brunswick	139
350	10	15241-694-1, -2	Wintec, Brunswick	147
396	10	F1D10182-01, -02	Vacco Industries	129
400	15	E-81916-4-15	Vacco Industries	120
400	10	15267-602	Wintec, Brunswick	148
415	25	15312-501-1	Wintec, Brunswick	151
415	25	15312-501-3	Wintec, Brunswick	152

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Pressure (psi)	Rating (μm abs)	Part Number	Manufacturer	Page
555	35	15228-572	Wintec, Brunswick	142
600	25	F1D10106-01	Vacco Industries	123
600	15	15241-685	Wintec, Brunswick	146
615	15	15241-647	Wintec, Brunswick	145
880	25	F1D10106-02	Vacco Industries	124
1000	40	F1D10132-01	Vacco Industries	125
1000	12	SL-81500	Vacco Industries	131
1765	15	AC-6875-855	Aircraft Porous Media	111
2000	10	14267-602	Wintec, Brunswick	140
3000	2x-200	4200T series	Norman Equipment	115
3000	2x-200	4300 series	Norman Equipment	116
3500	0.3	AC-A370-6	Aircraft Porous Media	108
3820	12	SL-81019	Vacco Industries	130
4000	12	F1D10178-01	Vacco Industries	127
4000	10	F1D10180-01	Vacco Industries	128
4000	15	S2-8846	Vacco Industries	132
4015	5	AC-6875-853	Aircraft Porous Media	110
4500	10 to 85	series 16510	Western Filter	134
5215	25	14228-502	Wintec, Brunswick	138
6000	-	F7008, F7009	Circle Seal Controls	112
6000	2x-200	4200T series	Norman Equipment	115
6000	10 to 75	series 6030	Western Filter	133

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Filter (continued)

Pressure (psi)	Rating (μm abs)	Part Number	Manufacturer	Page
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Compressor/Pump

Compression Ratio	Part Number	Manufacturer	Page
2.3:1	Model 50-503	Moog	160
2.36:1	33E08-1	Bendix	156
2.6:1	D41609	Metal Bellows	159
10:1	DX27312	Metal Bellows	158
22:1	P57228	Lexair	157
60:1	AP27V	Abex	155
100:1	AP05VC	Abex	154
-	AM3C	Abex	153

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Pressure Switch

Pressure switch off (psi)	Part Number	Manufacturer	Page
3.2	21SN04-93	Consolidated Controls	162
9.25	212C50-54H	Consolidated Controls	165
18	21SN04-22	Consolidated Controls	161
40	21SN41 series	Consolidated Controls	164
41.0	21SN22-1	Consolidated Controls	163
100	1103P, 1173P, 1193P	ITT Neo Dyn	168
300	2-54	Systron Donner	170
370	212C117-5	Consolidated Controls	166
600	1105P, 1106P	ITT Neo Dyn	169
5000	4-902	Systron Donner	171
(low pressure)			
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0.2 to 20 in. H_2O	610, 612	Systron Donner	172

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Check Valve

Pressure (psig)	Part Number	Manufacturer	Page
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15	P17-698	Circle Seal Controls	188
75	P75-356	Circle Seal Controls	194
120	P3-319	Circle Seal Controls	182
130	P64-344	Circle Seal Controls	193
215	119T1-1PP-35	Circle Seal Controls	195
250	2249B-2MM	Circle Seal Controls	203
300	4022	Aerodyne Controls	173
350	P25-180	Circle Seal Controls	190
450	60616-19A	Futurecraft	207
500	P24-698	Circle Seal Controls	189
600	859T-8TT	Circle Seal Controls	201
600	869A-8TT/GA, -8TT2	Circle Seal Controls	202
600	8524T-6BB	Circle Seal Controls	205
600	8538A-16BB-9	Circle Seal Controls	206
750	P6-180	Circle Seal Controls	183
1000	P14-735	Circle Seal Controls	186
1150	P45-220	Circle Seal Controls	192
1250	2662-0001-13, -15	Carleton Technologies	174
1700	P1-602, P2-602	Circle Seal Controls	181
2500	K5120T-16TT-38	Circle Seal Controls	180
3000	K220T-6TT, -12TT	Circle Seal Controls	179
3000	P29-180, P30-180	Circle Seal Controls	191

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Check Valve (continued)

Pressure (psig)	Part Number	Manufacturer	Page
3000	220T-8TT	Circle Seal Controls	197
3000	220T-24BB-3, 220T-32BB-3	Circle Seal Controls	196
3000	249A-4TT(L)-15	Circle Seal Controls	198
3000	259T-4TT	Circle Seal Controls	199
3000	264T2-8TT-25, 264T2-16TT-5	Circle Seal Controls	200
3000	2633A-4TT	Circle Seal Controls	204
3250	P8-690	Circle Seal Controls	185
4000	P7-425	Circle Seal Controls	184
4500	HP280T-4TF4	Circle Seal Controls	178
6000	H249T1-4TT(L)	Circle Seal Controls	175
6000	H299T-16BB	Circle Seal Controls	176
6000	HP220T-8TT to -16TT	Circle Seal Controls	177

FAST COMPONENT INDEX
Pressure Transducer/Gage

Max Pressure (psi)	Part Number	Manufacturer	Page
5	2653-0001-1, 2653-1001-5, 2653-2001-3	Carleton Technologies	208
18	2664-0001-11	Carleton Technologies	210
20	2730-0001-1	Carleton Technologies	211
20	2731-0001-5	Carleton Technologies	212
20	2767-0001-1	Carleton Technologies	215
100	4-930	Systron Donner	237
100	4-931	Systron Donner	238
150	(NAVORD)3064422	Consolidated Controls	229
200	41SG78-7	Consolidated Controls	221
300	2733-0001-1	Carleton Technologies	214
350	2-201	Systron Donner	233
400	41SG51-2	Consolidated Controls	220
1200	41SG51-1	Consolidated Controls	220
1500	2732-0001-1	Carleton Technologies	213
1500	210-75-XXX series	Paine	230
1700	41SG156-1700A1	Consolidated Controls	227
2000	4-910	Systron Donner	236
2500	41SG149-2500A1	Consolidated Controls	225
3300	2657-0001-1	Carleton Technologies	209
3500	41SG155-1	Consolidated Controls	226
3500	41SG156-3500A1, -3500A2	Consolidated Controls	228

FAST COMPONENT INDEX
Relief Valve

Pressure (psi)	Part Number	Manufacturer	Page
15	P13-533	Circle Seal Controls	243
16	2655-0001-5	Carleton Technologies	240
85	400233	Futurecraft	254
150	D500T series	Circle Seal Controls	242
150	P27-673	Circle Seal Controls	244
150	532T-4D-5	Circle Seal Controls	248
150	559B-X	Circle Seal Controls	250
150	559T-6D-18.8	Circle Seal Controls	251
200	3895	Aerodyne Controls	239
200	524T-2MP-7	Circle Seal Controls	247
250	P68-344	Circle Seal Controls	245
330	3111-0001-15	Carleton Technologies	241
400	520T1-8D-175	Circle Seal Controls	246
400	559A-1M-X	Circle Seal Controls	249
540	400214	Futurecraft	253
2500	5159T-4TT-155, 5159T-2MP-200	Circle Seal Controls	252

FAST COMPONENT INDEX
Pressure Regulator

Pressure		Part Number	Manufacturer	Page
Inlet (psi)	Regulated (psi)			
215	100	2344344	Tavco	299
295	14.7	2144-0001-31	Carleton Technologies	261
295	8	2144-0001-33	Carleton Technologies	262
295	16.25	2362-0001-11	Carleton Technologies	263
365	50	34810	Sterer Engineering	295
490	315	146650-10, 146931	HTL Industries	283
500	100	2328-1	Pyronetics	289
515	35	2834	Pyronetics	292
665	7.5	2346340	Tavco	301
865	20	227705	Whittaker	304
900	100	1-4-00-58-11	Carleton Technologies	255
900	100	1-4-00-58-15	Carleton Technologies	257
1250	100	1-4-00-58-13	Carleton Technologies	256
1300	10	1-59-00-3	Carleton Technologies	259
1750	246	5660048	Parker Hannifin	288
1800	43	1-59-00-5	Carleton Technologies	260
2000	12	2832	Pyronetics	291
2015	60	33120-1	Sterer Engineering	294
2015	255	50750	Sterer Engineering	297
2500	16	1826001-19	Carleton Technologies	268
3015	250	280601	Marotta Scientific	286
3015	470	280778	Marotta Scientific	287

FAST COMPONENT INDEX
Pressure Regulator (continued)

Pressure Inlet (psi)	Pressure Regulated (psi)	Part Number	Manufacturer	Page
3015	15	25210-1	Sterer Engineering	293
3015	375	234635	Tavco	298
3015	50	123035	Whittaker	303
3215	200	65-168	Fairchild Industries	272
3215	500	679000	Fairchild Industries	277
3261	5	601000	Fairchild Industries	275
3300	400/200	2726-0001-7	Carleton Technologies	266
3300	400/300	2729-0001-9	Carleton Technologies	267
3375	475	146650-11, 146709	HTL Industries	284
3515	240	332000	Fairchild Industries	273
3515	182	385000	Fairchild Industries	274
3515	285	994000	Fairchild Industries	278
3515	450	400176	Futurecraft	279
3600	475	400294	Futurecraft	282
3600	283	JPL 10000055	TRW	302
3655	247	6890	Consolidated Controls	269
3700	60	400236	Futurecraft	281
3815	700	2346334	Tavco	300
3915	38	617000	Fairchild Industries	276
4000	220	2566-0002-1	Carleton Technologies	265
4000	500	2828-0	Pyronetics	290
4015	255	6894	Consolidated Controls	270

FAST COMPONENT INDEX
Pressure Regulator (continued)

Pressure Inlet (psi)	Pressure Regulated (psi)	Part Number	Manufacturer	Page
4015	220	2566	Carleton Technologies	264
4500	630	226154	Marotta Scientific	285
4515	291	63-036	Fairchild Control	271
4515	25	46240	Sterer Engineering	296
4515	750	228045	Whittaker	305
5000	265	400210	Futurecraft	280
5000	1.2	1-29-00	Carleton Technologies	258

FAST COMPONENT INDEX
Heater/Heat Exchanger

Watts	Part Number	Manufacturer	Page

NO DATA

FAST COMPONENT INDEX
Line/Thruster Valve

Pressure (psi)	Part Number	Manufacturer	Page
14.7	2763-0001-9	Carleton Technologies	314
16	2710-0001-1	Carleton Technologies	311
16.7	2874-0001-3	Carleton Technologies	315
20	2724-0001-3	Carleton Technologies	313
20	P58-717	Circle Seal Controls	320
20	P76-717	Circle Seal Controls	321
40	15607-4	Wright Components	357
43	V27200-520	Valcor	347
45	15554	Wright Components	354
50	15637	Wright Components	362
60	15457-2, -5	Wright Components	351
75	15751	Wright Components	367
85	200916	Futurecraft	332
150	9213T-2PP	Circle Seal Controls	323
175	5720004	Parker Hannifin	343
210	50-438	Moog	337
225	15607-2	Wright Components	355
250	P79-717	Circle Seal Controls	322
250	50-353	Moog	334
250	15626-2	Wright Components	360
250	15626-4	Wright Components	361
255	P38-717	Circle Seal Controls	318
255	5720002	Parker Hannifin	342

FAST COMPONENT INDEX
Line/Thruster Valve (continued)

Pressure (psi)	Part Number	Manufacturer	Page
415	15726-7	Wright Components	365
420	51-109	Moog	338
420	51E110	Moog	339
450	200788-59, -69	Futurecraft	330
450	200851	Futurecraft	331
576	V27200-411	Valcor	346
600	-	Consolidated Controls	324
600	-	Consolidated Controls	326
1000	5720048	Parker Hannifin	344
1050	P54-717	Circle Seal Controls	319
1250	2722-0001-9	Carleton Technologies	312
2000	-	Consolidated Controls	328
3000	P9-649	Circle Seal Controls	316
3000	200787-39	Futurecraft	329
3300	2666-0001-23	Carleton Technologies	309
3300	2666-0001-25	Carleton Technologies	310
4500	Model 403	Abex	307
7500	P22-406	Circle Seal Controls	317

FAST COMPONENT INDEX
Gas Generator

FAST COMPONENT INDEX
Temperature Transducer

FITTING/CONNECTOR

MANUFACTURER
PART NUMBER (SERIES)

DESCRIPTION

CONFIGURATIONS

QUALIFICATION STATUS
PROPELLANT/FLUID

PRESSURE, OPERATING
PROOF
BURST
MASS

TUBE SIZE(S), O.D.

DIMENSIONS

MATERIAL, BODY
SEAL

TUBE-FITTING ATTACHMENT

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

TANK/ACCUMULATOR

MANUFACTURER_____
PART NUMBER_____
DESCRIPTION_____
QUALIFICATION STATUS_____
_____
PROPELLANT/FLUID_____

VOLUME_____
PRESSURE, OPERATING_____
PROOF_____
BURST_____
MASS_____
DIMENSIONS_____
_____
MATERIAL_____
_____
PORT(S), SIZE & TYPE_____
MOUNTING_____
EXPULSION METHOD_____

OPERATING TEMPERATURE RANGE_____
_____
VIBRATION, RANDOM_____
SINE_____
ACCELERATION_____
SHOCK_____

LIFE, SERVICE_____
CYCLE_____
SHELF_____
RELIABILITY_____
LEAD TIME_____
COST_____
REMARKS_____
_____
_____

DATA SOURCE_____
_____

SERVICE VALVE

MANUFACTURER
PART NUMBER
DESCRIPTION
QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, OPERATING
PROOF
BURST

RATED FLOW

LEAKAGE, INTERNAL

EXTERNAL

MASS

DIMENSIONS

MATERIAL, BODY
SEAT/SEAL TFE

CONNECTIONS, GROUND SIDE
SPACECRAFT SIDE
INTEGRAL FILTER
MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

FILTER

MANUFACTURER
PART NUMBER
DESCRIPTION

QUALIFICATION STATUS
PROPELLANT/FLUID
RATING, ABSOLUTE

PRESSURE, OPERATING
PROOF
BURST
DIFFERENTIAL

RATED FLOW

THROUGHPUT
LEAKAGE, EXTERNAL

MASS
DIMENSIONS

MATERIAL, BODY
ELEMENT

PORTS, INLET

OUTLET
MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

COMPRESSOR/PUMP

MANUFACTURER
PART NUMBER
DESCRIPTION

QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, MAX INLET
MAX OUTLET
RATIO
RATED FLOW
LEAKAGE, INTERNAL
MASS
DIMENSIONS

MATERIAL, BODY
SEALS
INTEGRAL CHECK VALVE
PORTS, SIZE & TYPE

MOTOR, VOLTS
WATTS
POWER OUTPUT
ELECTRICAL CONNECTION
RPM
DUTY CYCLE
COOLING METHOD
MOUNTING
OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

PRESSURE SWITCH

MANUFACTURER_____
PART NUMBER_____
DESCRIPTION_____
_____
QUALIFICATION STATUS_____
_____
PROPELLANT/FLUID_____

PRESSURE, OFF_____
RESET_____
MAX OPERATING_____
PROOF_____
BURST_____

DUTY CYCLE_____
MASS_____
DIMENSIONS_____
_____
MATERIAL_____
PORT, SIZE & TYPE_____
VOLTAGE_____
WATTS_____
ELECTRICAL CONNECTION_____
_____
MOUNTING_____
_____

OPERATING TEMPERATURE RANGE_____
_____
VIBRATION, RANDOM_____
SINE_____
ACCELERATION_____
SHOCK_____

LIFE, SERVICE_____
CYCLE_____
SHELF_____
RELIABILITY_____
LEAD TIME_____
COST_____
REMARKS_____
_____
_____
_____

DATA SOURCE_____
_____

CHECK VALVE

MANUFACTURER_____
PART NUMBER_____
_____
_____
DESCRIPTION_____
QUALIFICATION STATUS_____
_____
PROPELLANT/FLUID_____

PRESSURE, OPERATING_____
CRACKING_____
PROOF_____
BURST_____
RATED FLOW_____
_____
LEAKAGE, INTERNAL_____
EXTERNAL_____
MASS_____
DIMENSIONS_____
MATERIAL, BODY_____
SEAT/SEAL_____
SPRING_____
PORTS, SIZE & TYPE_____
_____
MOUNTING_____

OPERATING TEMPERATURE RANGE_____
_____
VIBRATION, RANDOM_____
SINE_____
ACCELERATION_____
SHOCK_____

LIFE, SERVICE_____
CYCLE_____
SHELF_____
RELIABILITY_____
LEAD TIME_____
COST_____
REMARKS_____
_____

DATA SOURCE_____

PRESSURE TRANSDUCER/GAGE

MANUFACTURER_____
PART NUMBER_____
DESCRIPTION_____
QUALIFICATION STATUS_____
_____
PROPELLANT/FLUID_____

PRESSURE, MAX_____
MIN_____
PROOF_____
BURST_____
MASS_____
DIMENSIONS_____
_____
MATERIAL_____
PORT, SIZE & TYPE_____
VOLTAGE, INPUT_____
WATTS_____
SIGNAL_____
ELECTRICAL CONNECTION_____
_____
MOUNTING_____
_____

OPERATING TEMPERATURE RANGE_____
_____
VIBRATION, RANDOM_____
SINE_____
ACCELERATION_____
SHOCK_____

LIFE, SERVICE_____
CYCLE_____
SHELF_____
RELIABILITY_____
LEAD TIME_____
COST_____
REMARKS_____
_____
_____

DATA SOURCE_____
_____

RELIEF VALVE

MANUFACTURER
PART NUMBER
DESCRIPTION

QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, RELIEF
RESET
RATED FLOW
LEAKAGE, INTERNAL
MASS
DIMENSIONS

MATERIAL, BODY
SEAT/SEAL
SPRING
PORTS, SIZE & TYPE

MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

PRESSURE REGULATOR

MANUFACTURER
PART NUMBER
DESCRIPTION
QUALIFICATION STATUS

PROPELLANT/FLUID
PRESSURE, RANGE, INLET
REGULATED
OUTLET-LOCKUP
PROOF, INLET
PROOF, OUTLET
BURST, INLET
BURST, OUTLET
DROP
RATED FLOW
LEAKAGE, INTERNAL-MAX INLET PRESS

EXTERNAL-MAX INLET PRESS
MASS
DIMENSIONS

MATERIAL, BODY
SEAT/SEAL

SPRING
PORTS, SIZE & TYPE, INLET

OUTLET

INTEGRAL RELIEF

INTEGRAL FILTER
MOUNTING

OPERATING TEMPERATURE RANGE
VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

HEATER/HEAT EXCHANGER

MANUFACTURER
PART NUMBER
DESCRIPTION
QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, OPERATING
PROOF
BURST
RATED FLOW
MASS
DIMENSIONS

MATERIAL, BODY
HEATING ELEMENT
PORTS, SIZE & TYPE
VOLTAGE
WATTS, IN
OUT
ELECTRICAL CONNECTION
DUTY CYCLE
MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

LINE/THRUSTER VALVE

MANUFACTURER
PART NUMBER
DESCRIPTION
QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, OPERATING
PROOF
BURST
DROP
RATED FLOW

LEAKAGE, INTERNAL
EXTERNAL
MASS
DIMENSIONS

MATERIAL, BODY
SEAT/SEAL
PORTS, SIZE & TYPE

INTEGRAL FILTER
RESPONSE TIME, OPEN/CLOSE
VOLTAGE, OPERATING
PULL IN/DROP OUT
WATTS
ELECTRICAL CONNECTION
MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

GAS GENERATOR

MANUFACTURER
PART NUMBER
DESCRIPTION

QUALIFICATION STATUS

PROPELLANT/FLUID

PRESSURE, OPERATING
CHAMBER
PROOF
BURST
RATED FLOW
TOTAL THROUGHPUT
TOTAL IMPULSE
MASS
DIMENSIONS

MATERIAL, BODY
CATALYST/CORE

PORTS, SIZE & TYPE
VOLTAGE
WATTS
ELECTRICAL CONNECTION
DUTY CYCLE

MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

TEMPERATURE TRANSDUCER

MANUFACTURER
PART NUMBER
DESCRIPTION
QUALIFICATION STATUS

PROPELLANT/FLUID

INDICATED TEMPERATURE, MAX
MIN
PRESSURE, OPERATING
PROOF
BURST
MASS
DIMENSIONS

MATERIAL
PORT, SIZE & TYPE
VOLTAGE, INPUT
WATTS
SIGNAL
ELECTRICAL CONNECTION
MOUNTING

OPERATING TEMPERATURE RANGE

VIBRATION, RANDOM
SINE
ACCELERATION
SHOCK

LIFE, SERVICE
CYCLE
SHELF
RELIABILITY
LEAD TIME
COST
REMARKS

DATA SOURCE

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TABLE I IOC PLUS GROWTH STATION ANNUAL WASTE GAS PRODUCTION/ BOSCH ECLSS (lbm/year)

FLUID	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
(BOSCH ECLSS)										
ARGON	1264	1264	1264	1264	1348	1348	1348	1026	1026	1109
CO2	208	208	208	451	745	503	260	260	260	312
CO2/CH4	0	0	0	0	0	0	0	0	0	0
FREON	6	6	6	6	8	8	8	8	8	9
HELIUM	36	36	124	896	813	813	813	813	813	817
HYDROGEN	182	182	322	322	702	394	254	254	254	325
NITROGEN	1680	1680	1680	1835	2647	2483	2338	2108	2108	2765
OXYGEN	243	243	243	243	335	335	335	335	335	426
XENON	88	88	88	88	110	110	110	110	110	132
KRYPTON	80	80	80	80	80	80	80	80	80	80
TOTALS:	3787	3787	4015	5185	6788	6084	5546	4994	4994	5975

TABLE II IOC PLUS GROWTH STATION ANNUAL WASTE GAS PRODUCTION/ SABATIER ECLSS (lbm/year)

FLUID	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
(SABAT.ECLSS)										
ARGON	1264	1264	1264	1264	1348	1348	1348	1026	1026	1109
CO2	208	208	208	451	745	503	260	260	260	312
CO2/ CH4	2256 / 1484	2256 / 1484	2256 / 1484	2256 / 1484	3384 / 2226	3384 / 2226	3384 / 2226	3384 / 2226	3384 / 2226	4512 / 2968
FREON	6	6	6	6	8	8	8	8	8	9
HELIUM	36	36	124	896	813	813	813	813	41	45
HYDROGEN	42	42	182	182	492	184	44	44	44	45
NITROGEN	1680	1680	1835	2647	2493	2338	2338	2108	2108	2765
OXYGEN	243	243	243	243	335	335	335	335	335	426
XENON	88	88	88	88	110	110	110	110	110	132
KRYPTON	80	80	80	80	80	80	80	80	80	80
TOTALS:	7569	7569	7937	9107	12890	11878	10946	10394	10394	13195

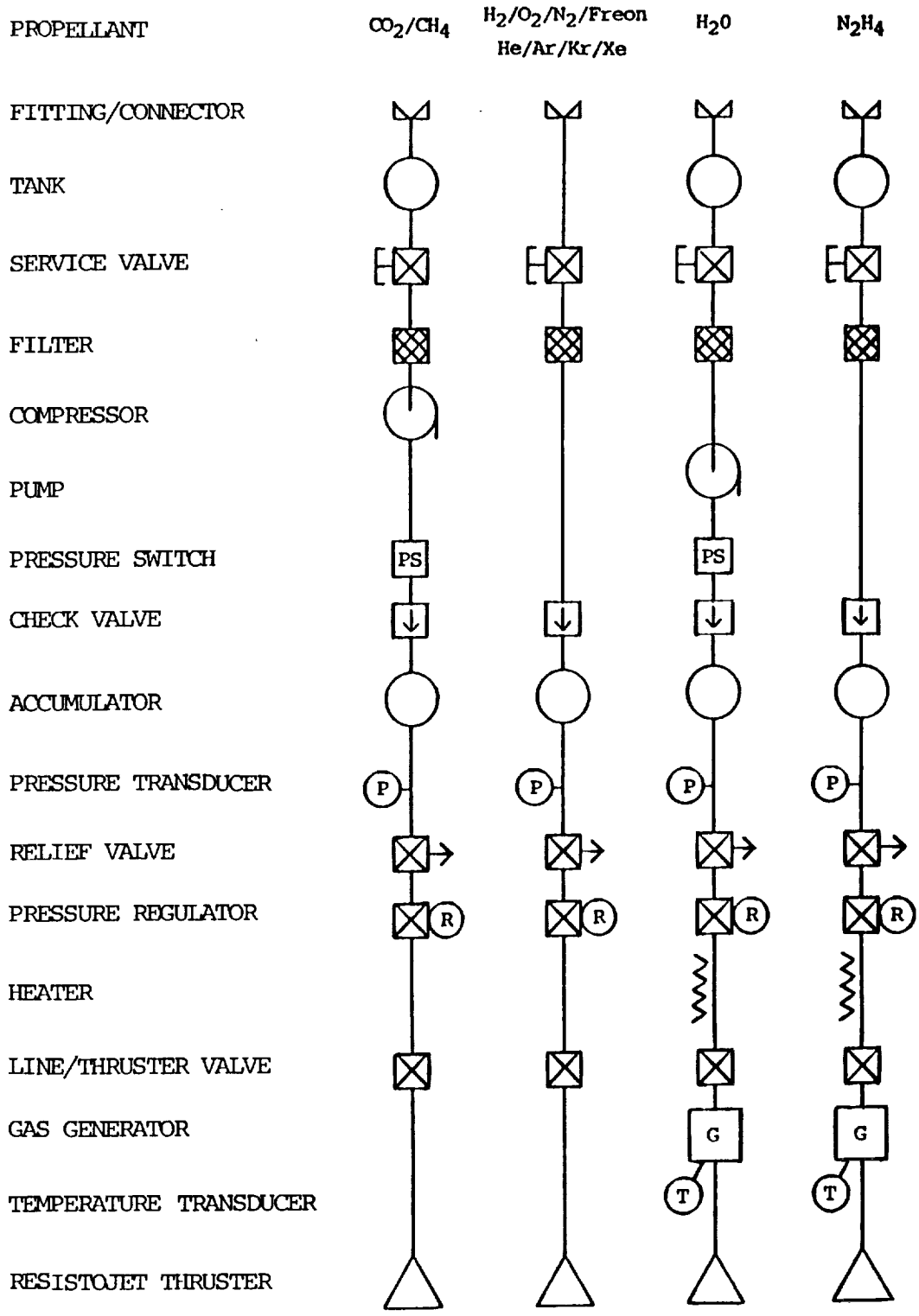

FIGURE 1. Simplified Component/System Comparison
(Note: Order and number of components in system may vary, and components may be deleted.)

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16. Abstract

The resistojet has been baselined for Space Station auxiliary propulsion because of its operational versatility, efficiency, and durability. This report was conceived as a guide to designers and planners of the Space Station auxiliary propulsion system. It is directed to the low thrust resistojet concept, though it should have application to other station concepts or systems such as the Environmental Control and Life Support System (ECLSS), Manufacturing and Technology Laboratory (MTL), and the Waste Fluid Management System (WFMS). The report will likely be quite useful in the same capacity for other non-Space Station systems including satellites, freeflyers, explorers, and maneuvering vehicles. The report is a catalog of the most useful information for the most significant feed system components and is organized for the greatest convenience of the user.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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